Analog multiplex systems: The basics

Part 1 — Multiplexing combines multiple discrete signals into one composite transmission. Familiarity with direct-to-line systems enhances a technician's repertoire.

By Jeff Ashley

A common complaint for employers in today's communications industry is not being able to find *qualified* technicians. Years ago, two-way field technicians might have been considered "qualified" by merely having experience with Micors or Master IIs—not so today. Employers are looking for people whose experience extends to microwave and multiplex systems. Those seeking employment must be willing to expand their knowledge base if they expect to be marketable. Two-way technicians who are *currently* employed must be willing to expand their responsibilities to maintain job security.

With this in mind, let's take a brief and practical look at the subject of analog multiplex systems, which can prove valuable to those yet unfamiliar with such transmission systems equipment.

Ashley is a communications technician in Los Angeles.

Analog mux—FDM

Frequency-division multiplexing (FDM) is, and has been for quite some time, a common analog method of combining or encoding multiple discrete signals into one composite transmission signal. Analog microwave radio systems are the typical transport mechanisms for FDM systems. The multiplex (mux) equipment provides the means for interfacing the individual circuits (radio, voice or data) with the microwave radio. For every circuit transported over the microwave system, a corresponding mux channel modem will be on each end of the circuit.

In general, there are two types of FDM systems: *basic* and *direct-to-line*. Basic FDM systems preceded the arrival of direct-to-line equipment by decades. The architecture of these older systems typically requires multiple equipment racks to accommodate all the individual, interconnected units necessary for each step of the multiplex process.

Over the years, advances in technology and miniaturization of circuitry made possible the direct-to-line method that offers the same end result with significantly less equipment. Direct-to-line systems allow companies with minimal channel requirements to obtain multiplex equipment on a per-channel basis rather than as a full-blown system made to accommodate hundreds of channels, whether you need them all or not.

Because of their cost-effectiveness, direct-to-line systems are probably what today's communications technician will encounter. For this reason, basic FDM systems will only be mentioned briefly as a backdrop to the more modern and popular direct-to-line systems.

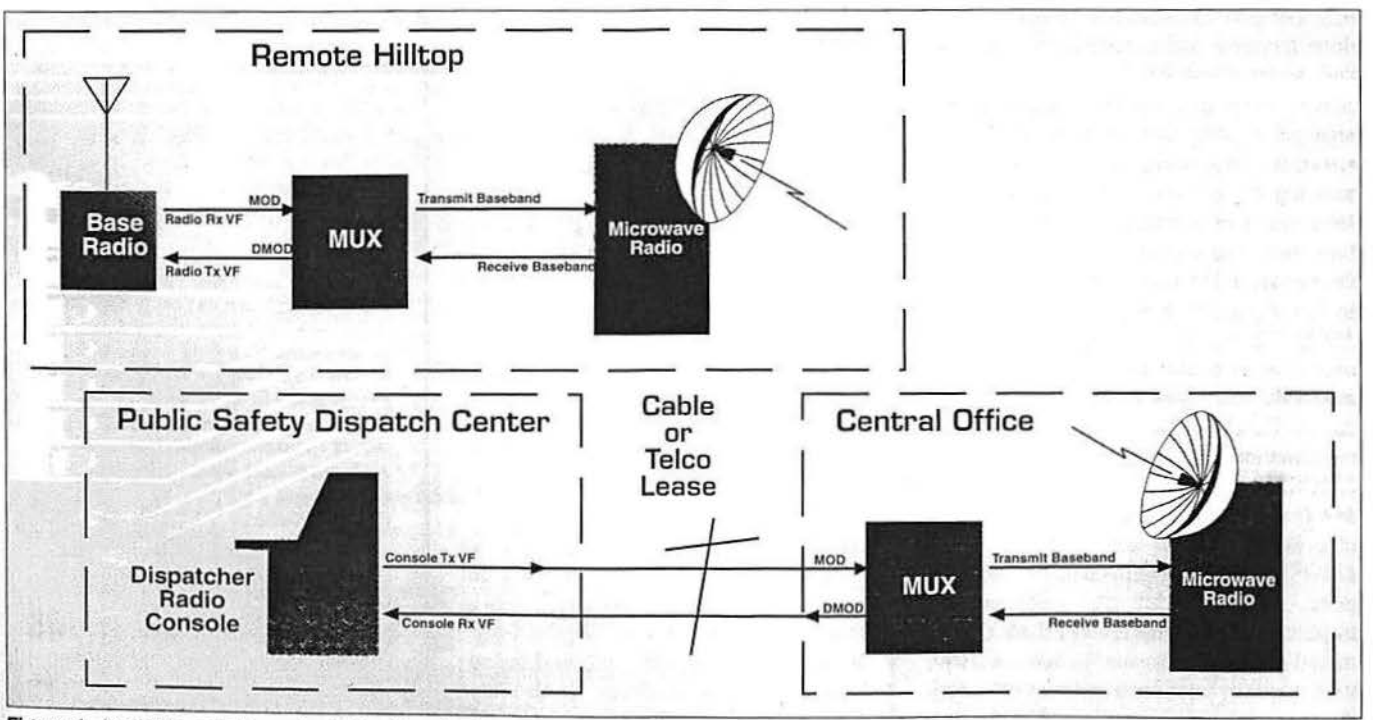


Figure 1. Possible remote-controlled radio circuit.

VF and signaling

Multiplex and microwave systems are often referred to as *transmission systems* equipment because they provide a method of transmitting broadband signals from one point to another. A common term used in the transmission systems field is "VF," short for "voice frequency." A VF signal is the audio information being carried over a circuit. The VF transmit connection to the mux channel modem is referred to as the *MOD* while the receive connection is the *DMOD*. (See Figure 1 on page 72.)

In addition to VF signals, the mux circuit often carries information called *signaling*, which relates supervisory information from one end of the circuit to the other. Using a subscriber telephone circuit as an example, a method is needed to *signal* the central office as to whether the phone is on- or off-hook, or to activate ringing. Radio circuit signaling is used to convey the push-to-talk (PTT) function from the dispatcher console to the remote base station. VF and signaling can be accomplished over the same multiplex channel at the same time.

The primary mux modem signaling connections are referred to as the *M-lead (transmit)* and *E-lead (receive)*. Although modem-strapping options usually accommodate alternate arrangements, transmit signaling is typically activated by applying battery (the modem's operating voltage) to the M-lead connection. When signaling is detected from the far-end mux modem, the local E-lead is activated, which most often applies a ground to its external connection. As with the M-lead, onboard E-lead strapping options usually allow for alternatives such as the internal battery voltage to be sent out to the external connection. In some cases, mux modems are equipped with an *F-lead* that allows some other external voltage level to be applied to the modem, which can then be gated out the E-lead when signaling is detected. This is an advantage when the external device activated by the E-lead requires a specific voltage that is not obtainable from the mux modem itself.

VF frequency response

The frequency response of speech can range from about 100Hz to 8kHz. However, the primary components necessary for speech recognition are contained below 3kHz. The typical analog mux channel has a circuit frequency response of 300Hz to 3,400Hz. Frequencies above and below this range are rolled off with filters.

FDM—direct-to-line method

In direct-to-line systems, the whole multiplexing process takes place in one unit, the mux channel modem. (See Figure 2 below.)

Signals are transmitted to a far-end location by applying analog circuit information (VF) to the MOD of the mux channel. The modem processes the signal through a limiter stage to prevent excessive levels from overdriving the following circuits. The VF signals are then routed through a high-and-low-pass filter to give the desired 300Hz to 3,400Hz frequency response. A VF amplifier stage follows and allows adjustment of the transmit VF levels. The VF signal is applied to one port of the first balanced modulator while an IF oscillator (typically in the 3MHz to 6MHz range) is injected into another. The resultant mix translates the original 300Hz-to-3,400Hz VF signal into the RF spectrum as a double-sideband, suppressed-carrier (DSBSC) signal. A crystal filter then eliminates the unwanted sideband, leaving a single-sideband, suppressed carrier (SSBSC) signal occupying a 4kHz bandwidth.

This modulated signal is then applied to a second balanced modulator stage that again produces a DSBSC signal whose unwanted sideband and suppressed carrier are eliminated by filtering. The final result is a SSBSC signal modulated with the original VF circuit information. At this point, the signal is considered HF (high frequency), rather than VF.

Each mux circuit has the same first IF frequency. The second modulator, however, has a different and unique frequency injected for each channel in the system. This prevents one mux channel from interfering with another by ending up on the same frequency in the HF spectrum. To accommodate this, the second oscillator (which typically covers the 4MHz to 8MHz range) is a dip-switch programmable, phase-lock-loop circuit allowing frequency adjustment in 4kHz steps. Spectrally, the channels form a *collection* of adjacent HF frequency slots, one for each circuit. Each slot has a bandwidth of 4kHz and contains the modulated VF signals unique to that circuit. The spectral composite of all circuits in the system is referred to as the "baseband."

The mux channel modems on both ends of the *same circuit* must have their programmable oscillators set to the same frequency so that one end can communicate with the other. The baseband channel slots follow a CCITT-recommended scheme that establishes a standard for channel placement

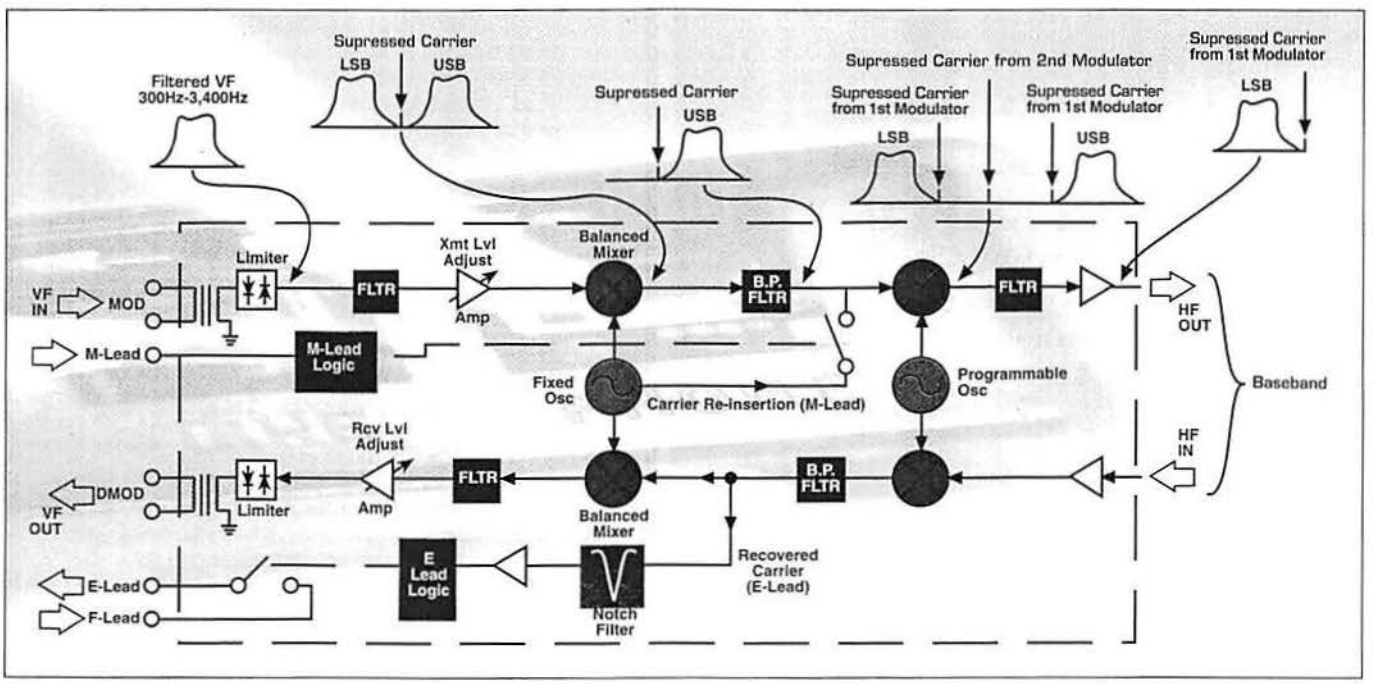


Figure 2. Direct-to-line mux channel modem.

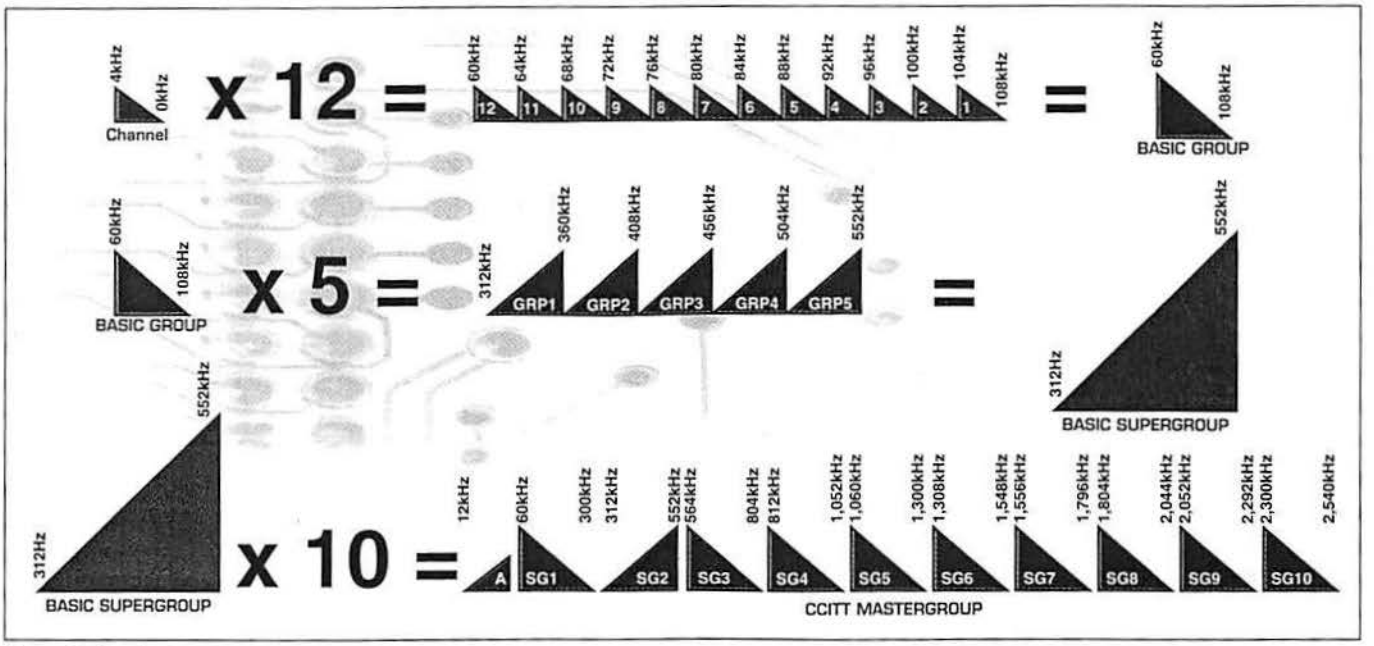


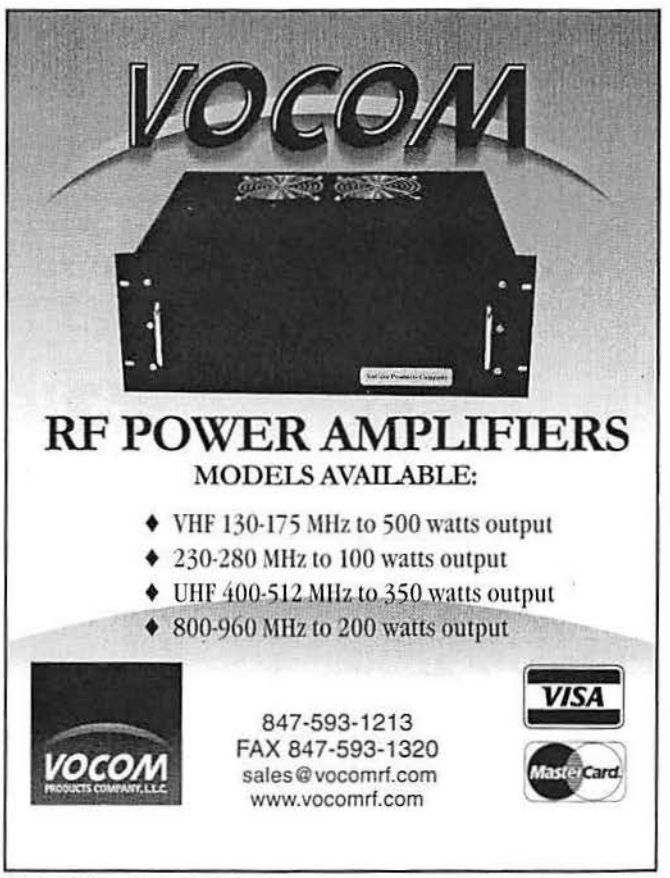
Figure 3. Basic groups.

within the baseband spectrum.

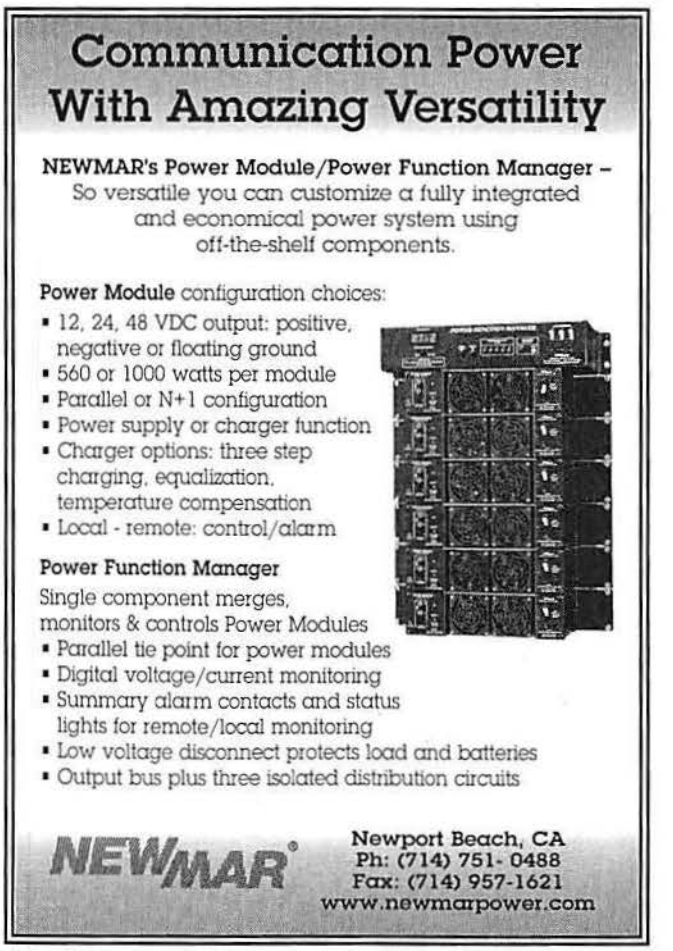
Once multiplexed to the proper frequency slots on the baseband, the circuits may be transmitted to the distant-end by means of an analog microwave radio transmitter. The mux system baseband is connected to the transmitter through a coaxial cable, which in this case would be referred to as the *transmit* baseband cable. At the distant-end, the baseband signals are demodulated through the microwave receiver. They are then applied, via the *receive* baseband cable, to a complementary FDM system. Here, the HF baseband signals are de-multiplexed through a process identical to the multiplexing of the opposite end, only in reverse. The end result is a recovered VF waveform the same as that applied to the mux channel MOD on the distant end.

Groups, supergroups and mastergroups

Basic mux systems accomplish the multiplexing process through a standardized series of intermediate steps within a variety of



Circle (65) on Fast Fact Card Visit us at IWCE, Booth #1901


Communication Power
With Amazing Versatility
NEWMAR's Power Module/Power Function Manager –
So versatile you can customize a fully integrated
and economical power system using
off-the-shelf components.
Power Module configuration choices:
▪ 12, 24, 48 VDC output: positive, negative or floating ground
▪ 560 or 1000 watts per module
▪ Parallel or N+1 configuration
▪ Power supply or charger function
▪ Charger options: three step charging, equalization, temperature compensation
▪ Local - remote: control/alarm
Power Function Manager
Single component merges, monitors & controls Power Modules
▪ Parallel tie point for power modules
▪ Digital voltage/current monitoring
▪ Summary alarm contacts and status lights for remote/local monitoring
▪ Low voltage disconnect protects load and batteries
▪ Output bus plus three isolated distribution circuits
NEWMAR
Newport Beach, CA
Ph: (714) 751-0488
Fax: (714) 957-1621
www.newmarpower.com

Circle (66) on Fast Fact Card Visit us at IWCE, Booth #515

separate, but interconnected, units.

Channel units are shelved in groups of 12. Each unit in the shelf has a different carrier frequency injected into its modulator stage by external *channel carrier generator units*. The result is a group of 12 channels translated one above the other with respect to frequency, occupying 48kHz of bandwidth between 60kHz and 108kHz. At this point the 12 channels are referred to as a *basic group*. Because each basic group occupies the exact same frequency range, they must be cabled separately to the next stage in the process to avoid interfering with one another.

These basic groups are modulated up to yet a higher frequency range, five at a time. Each group has a different injection frequency applied from its respective *group carrier generator unit*. The result is five groups (of 12 channels each) stacked one above the other with regard to frequency. The five groups are now referred to as a *basic supergroup* and occupy 240kHz of bandwidth between 312kHz and 552kHz.

Each basic supergroup occupies the same frequency spectrum and must, as with the basic group equipment, be cabled separately to the next stage.

Basic supergroups are then applied, in sets of 10, to higher-level translation equipment. Different injection carrier frequencies are again supplied, this time by *supergroup carrier generator units*. The results are 10 supergroups stacked one above the other on the baseband, now referred to as a *mastergroup*.

The translation processes can continue beyond the mastergroup level. For industrial applications, however, this is typically the greatest required channel capacity (600 channels).

Each translation process produces sum and difference frequencies that correlate to upper and lower sideband signals. As seen in Figure 3 on page 74, the CCITT modulation scheme dictates upper sideband (USB) for Supergroup Two while the others are lower sideband (LSB).

Unassigned spectrum is left available below 60kHz and can be used for additional channel assignments. The 12kHz–60kHz portion of the baseband is referred to as Group A. Like Supergroup Two, Group A comprises USB channels. The 0kHz–4kHz portion of the baseband is used as a maintenance communications channel on the microwave system, called an *order wire*. It allows communication between technicians at different microwave sites sharing the same baseband. Two more channels can be used in the 4kHz–12kHz spectrum. Often, remote alarm monitoring & control systems occupy one of these channel slots.

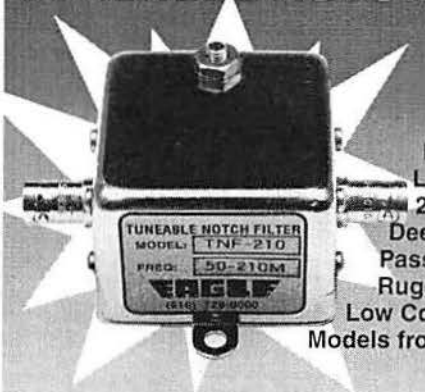
Synchronization

In both basic and direct-to-line FDM systems, *pilot* tones can be placed on the baseband for synchronization between the central office and the remote-end mux locations. A pilot is a specific frequency tone such as 60kHz, 64kHz, 308kHz, 512kHz or 564kHz, sent at a specific level. Once received at the remote site, the pilot tone frequency is divided down and used as a reference for the remote-end multiplexing and demultiplexing processes.

Synchronization can also be achieved through master/slave strapping on the mux channel modem. A channel modem, strapped as the slave, locks onto the master's signaling tone frequency. The master tone frequency is used within the slave channel modem for the multiplexing and demultiplexing processes.

Whichever method is used, the purpose of synchronization is to *eliminate translation* error between the two ends of the circuit. Excessive translation error on a voice circuit makes the party on the other end of the circuit sound like Donald Duck. Those familiar with tuning VFOs on SSB receivers will recognize the sound. ■

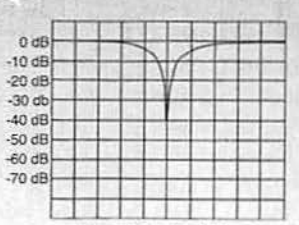
TUNEABLE NOTCH FILTERS



FEATURES:

Low VSWR:<1.2:1
Low Loss: <0.5 dB
25 Watt pass band
Deep Notch to 35 dB
Pass band to 3.0 GHz
Rugged Construction
Low Cost: starts at $125
Models from 0.5 to 850 MHz

The TNF200 filters are available in nine models from 0.5 MHz to 850 MHz. While primarily designed to improve the dynamic range of spectrum analyzers, these filters can also be used to reduce parasitics; or to eliminate or identify out of band interference in communications systems.



Plot of Typical Notch

Please call for FREE application note: "Spectrum Analyzer Measurements"

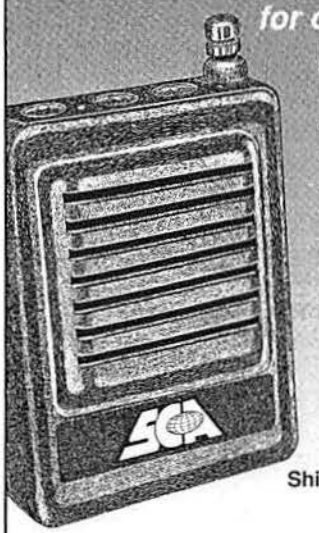
EAGLE

VOICE: (520) 204-2597 ♥ FAX: (520) 204-2568
P.O. BOX 4010 ♥ SEDONA, ARIZONA 86340

Circle (67) on Fast Fact Card

TONE AND VOICE
SCEPTAR

Providing Tone and Voice Pagers for over twenty years



Features:
- Synthesized, PC Programmable
- 2-Channel Operation
- Multi-Address Format
- Channel Monitoring Capability
- Vibrate Option
- Small Size—3-1/8" x 2-7/16" x 3/4"
- Single "AA" Battery
- 2-3 Year Limited Warranty Available

SCA

Shinwa Communications of America Inc.
P.O. Box 26407
Oklahoma City, OK 73126

ORDER TOLL FREE: 1-800-627-4722
FAX TOLL FREE 1-800-759-1722

Circle (68) on Fast Fact Card

Analog multiplex systems: The basics

Part 2 — Technicians need familiarity with modem circuitry, signaling formats and proper signal levels when servicing multiplex systems.

By Jeff Ashley

Today's two-way radio field technicians have increased responsibilities that extend to maintenance and installation of multiplex equipment. As such, they encounter terminology and a variety of circuit configurations that are foreign to the two-way industry.

Four-wire & two-wire circuits

Most communications circuits are designed to send *and* receive information, often at the same time. Analog multiplex (mux) systems accomplish this full-duplex operation through use of a *four-wire (4W)* mux modem. The modem has separate transmit and receive circuitry, providing isolation between the two. The term *4W* comes from the number of VF wire connections made to the mux channel modem. Because the MOD and DMOD are balanced connections, each requires two wires, totaling four, hence the term *4W*. (See Figure 1 below.)

Ashley is a communications technician in Los Angeles.

In the case of a telephone instrument or other *two-wire (2W)* device, the transmit and receive signals are carried on a single, balanced pair of wires. A 2W circuit must be converted to 4W when being applied to a transport system having separate receive and transmit circuitry. This conversion is accomplished through a 2W/4W hybrid circuit that is a three-port transformer arrangement. The telephone connects to the 2W port, while the mux modem connects to the 4W receive and transmit ports.

Signaling—in-band & out-of-band

Circuits usually require supervisory information (*signaling*) to be transmitted along with VF. The two basic signaling types used in frequency-division multiplexing (FDM) systems are *in-band* and *out-of-band* signaling.

In-band signaling occurs when supervisory information is sent within the normal 300Hz to 3,400Hz circuit passband. Using a subscriber telephone circuit as an example, a 2,600Hz tone can be sent from the far-end mux channel to the central office (CO), indicating the phone is "on-hook." When the phone is taken off-hook, the 2,600Hz signal is dropped. The CO equipment senses the absence of the tone and sends dial tone back out to the far-end.

In the case of remote base station keying, a 2,175Hz tone is frequently used. *Presence* of the tone activates the transmitter. The 2,175Hz signal is present for the duration of the radio broadcast to maintain the radio push-to-talk (PTT) function. The tone is within the normal VF passband of the mux circuit and is therefore considered in-band signaling. Because the tone is present during the entire broadcast, the tone must be notched out prior to the base station exciter stage, or it will be transmitted out over-the-air along with the voice.

Out-of-band signaling is achieved by moving the signaling tone frequency outside the 300Hz to 3,400Hz VF passband (but still within the 4kHz channel slot). A common example of this is the use of a 3,825Hz signaling tone.

Out-of-band signaling can also be accomplished by re-insertion of the suppressed

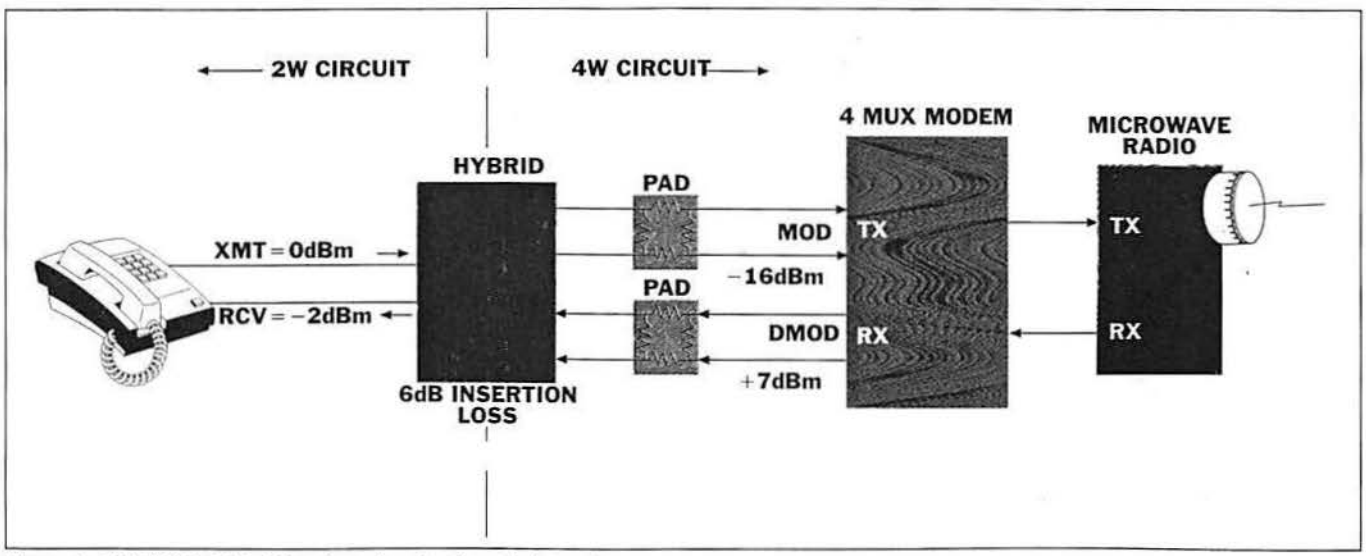


Figure 1. 2W/4W hybrid. (Signaling circuitry is not shown.)

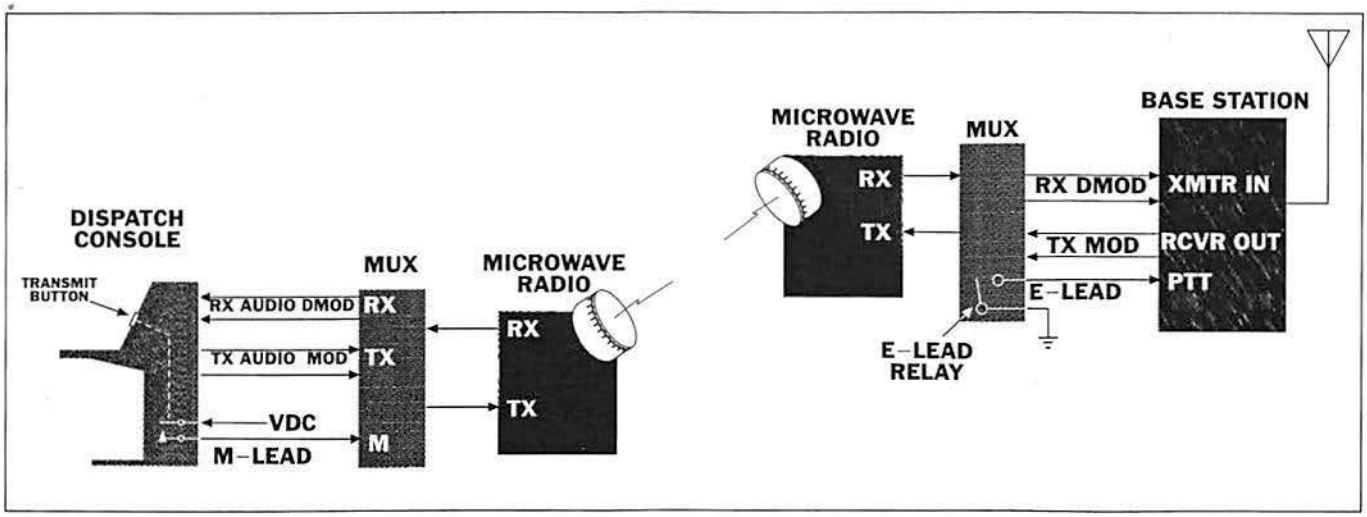


Figure 2. E-lead and M-lead signaling

carrier from the mux modem's first balanced modulator stage. Raising and dropping the level of the suppressed carrier on one end of the circuit can activate and de-activate signaling functions on the far-end. In this case, the signaling frequency will be located on the extreme edge of the allotted 4kHz channel slot.

Carrier leak is a term relating to the amount of residual suppressed carrier left in the mux modem transmit signal when the suppressed carrier level has not been raised for signaling. Since this carrier level can be detected and used in the signaling scheme, it is important to keep it suppressed as much as possible to prevent "falsing" when signaling is not activated. Often, the mux channel modem will have an adjustment for minimizing carrier leak when signaling is not activated.

Signaling—E- & M-leads

The mux modem connections that relate to signaling are the *E- & M-leads*. The *E-lead* connection is dedicated for receive signaling use, while the *M-lead* is for transmit.

Typically, the mux modem transmits signaling to the far-end when a voltage is applied to its M-lead connection. The far-end modem detects the signaling and activates its E-lead. Usually, the mux modem is equipped with an E-lead relay that supplies external supervisory equipment with a dry set of relay contacts.

Figure 2 above offers an example of E & M signaling. A radio dispatch console

...and the award for Outstanding Performance in a Critical Role goes to...
"Stripes of Quality"
Mosaic™
MODULAR ANTENNAS
Simplifies purchasing. Modular components reduce investment and inventory costs, while allowing for stocking flexibility
Improves performance across all VHF and UHF channels
Choice of patented Dura-Flex® spring or new cost effective springless model
When performance really matters, turn to the communication specialists—Antenna Specialists.
ALLEN TELECOM
ANTENNA SPECIALISTS
30500 Bruce Industrial Pkwy
Cleveland, Ohio 44139-3996
440-349-8400
FAX: 440-349-8407
800-664-5274
www.allentele.com
ISO9001

Circle (30) on Fast Fact Card

Visit us at IWCE, Booth #821

is connected to mux so that when the console operator wishes to key up a hilltop transmitter, a button on the console is pressed. This applies a voltage to the mux channel M-lead connection, causing the modem to send M-lead signaling out to the hilltop mux via microwave. The coordinate mux modem on the hilltop detects the M-lead signal and energizes its E-lead relay. The E-lead relay contacts close and apply a ground to the radio PTT line. The hilltop base station keys up, and the dispatcher can make the broadcast.

VF transmission levels

It is important to maintain proper signal levels within an analog multiplex system. The term *test tone level (TTL)* describes the maximum signal level that should exist at any point within an analog mux circuit to avoid creating intermodulation distortion components throughout the baseband. Test tone level is sometimes also referred to as *test level point (TLP)*.

Levels of "live traffic" can fluctuate greatly, depending on the circuit application. For this reason, they are not often a useful reference when making critical circuit level measurements and adjustments. Instead, maintenance personnel must inject an external, constant-level test tone (typically, 1,004Hz) into the circuit. However, this is an intrusive method that disrupts normal circuit operations. As circuit gain and loss tests are performed, levels exceeding expected values are referred to as *hot*, while those which are low are referred to as either *low*, *cold* or *long*.

As shown in Figure 1, TTL for a 2W circuit in the transmit direction is 0dBm, which produces a −16dBm level at the mux MOD. If +7dBm is delivered from the mux DMOD, it should produce a receive level of −2dBm on the 2W side of the hybrid. The standard test tone level for a 4W channel modem is −16dBm into the MOD and +7dBm out of the DMOD.

In transmission systems, the term *dBm0* is frequently used to refer to the difference (in decibels) between TTL and the absolute level (in decibels relative to 1mW) being measured. For example, if a base station status tone that has an absolute level of −26dBm is applied to the MOD of a mux channel, the level is said to be "−10dBm0" at that point in the circuit. Another way to express this is to say the level at the MOD is "10dB below test tone level." Assuming proper system alignment, this status tone will come out of the far-end mux DMOD at the same −10dBm0 level. Since TTL at the DMOD is always +7dBm, the absolute level (in dBm) of the status tone can be calculated: +7dBm−10dB = −3dBm. Even though the absolute input and outputs levels of the MOD and DMOD are different (−26dBm vs. −3dBm) they both retain the same *reference* to test tone level (−10dBm0). For this reason, the term *dBm0* is handy to use.

The third and final part of this series will consider VF and HF connections to analog mux systems, as well as typical test equipment found in the analog transmission systems environment. ■

EXPECT Change...

solutions from Zetron

Invest in a dispatch console that expects to be modified, expanded, rearranged, and updated-- one that will easily accommodate your evolving needs.

Consoles Need more operators? Add one or several desktop, rackmount or video operating positions to your Zetron common control equipment. Mix or match them to best suit your dispatch needs.

Keys Take advantage of "any button, any function" field programmability. Add or change frequencies, control functions, page stacks, alerts, priority tones, transmit groups, or auxiliary I/O.

Capacity Planning on adding more base or control stations? Expand your Series 4000 up to 48 radio or telephone channels.

Control Migrating to a trunked radio system? The Series 4000 product family includes interfaces for several popular protocols, including Motorola's iDEN™ and Ericsson's EDACS®, as well as industry common standards such as tone remote, DC, local, and E&M.

We Help You Master the Challenge of Change!

Zetron, Inc. ZETRON®

PO Box 97004, Redmond WA 98073-9704 USA ■ Phone 425-820-6363
Fax 425-820-7031 ■ Email ps@zetron.com ■ Web www.zetron.com

Circle (32) on Fast Fact Card

Visit us at IWCE, Booth #1303

Analog multiplexing series

This is part of a three-part series on analog multiplex systems.

Part 1: "Analog Multiplex Systems: The Basics," April 1999.
Part 2: "Analog Multiplex Systems: The Basics," May 1999.

Back issues printed within the last two years can be ordered for $10 each, postpaid. Call customer service at 800-441-0294. Issues printed more than two years ago and individual article photocopies are not available from the publisher. Individual copies of articles printed since January 1987 can be ordered from UMI at 800-248-0360.

Analog multiplex systems: The basics

Part 3 — Active analog mux systems are still in widespread use. An understanding of basic testing and troubleshooting techniques can distinguish a technician.

By Jeff Ashley

Equipped with a basic understanding of analog multiplex (mux) systems, two-way radio technicians can take the leap toward extending their duties beyond base station maintenance and into transmission systems.

This three-part series concludes with a brief discussion of mux system connections, VF and HF considerations and practical testing and troubleshooting techniques.

VF jackfield

External circuits that interface with a mux modem should do so through a VF jackfield. The jackfield allows the "end equipment" (base station, telephone, etc.) to be isolated from the mux modem for testing purposes. There should be jack positions for the MOD, DMOD, and E & M leads of each mux channel. (See Figure 1.)

Ashley is a communications technician in Los Angeles.

The top jacks are wired to the mux channel modem and are referred to as the *line* side of the jackfield. These jacks allow VF level testing into the mux modem MOD or out from the DMOD. The bottom jacks are referred to as the *drop* side of the jackfield.These jacks allow VF level testing into and out of the drop ("customer") equipment. Without any test cords plugged in, the jackfield internally connects the line side to the drop side. If a test cord is inserted into either the line or drop jacks, the internal connection is broken and the two sides are electrically isolated.

The balanced connections to and from the VF jackfield have a circuit impedance of 600Ω. When test equipment is plugged into either the line or drop jacks, the instrument should have an internal *terminating* impedance of 600Ω. Because the line and drop jacks *break* (isolate) the two sides of the circuit, this allows the side under evaluation to be properly terminated into the test equipment for accurate measurements. A common mistake is to have the test equipment set up in the *bridging* rather than *terminating* mode when plugged into a *breaking* jackfield. This will not offer the proper termination to the circuit, and it will result in level readings being +6dB hotter than what actually exists without the test equipment in the circuit.

Often, a third *monitor* jack is located beneath the VF line and drop jacks. Plugging test equipment into this jack will *not* break the circuit, but it puts the test equipment in parallel with it. In this case, the test equipment must be put in the *bridging* mode to avoid a *double-termination* to the circuit under test. A double-termination will result in readings that are −3dB lower than what actually exists when the test equipment is removed.

When measurements indicate levels are *−3dB lower or +6dB hotter* than expected, the test equipment *terminating/bridging* mode switch should be checked. The mode

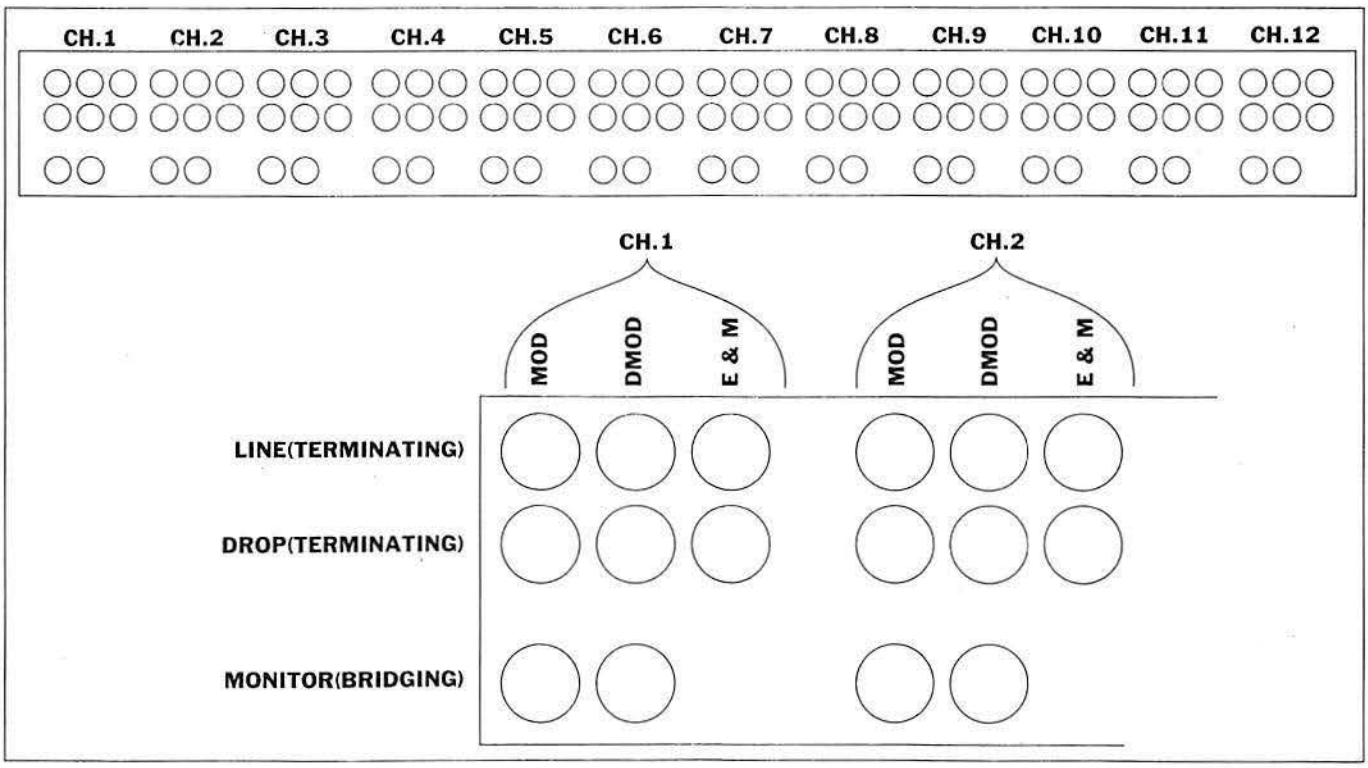


Figure 1. VF jackfield.

switch only affects the receive portion of the test equipment.

VF test equipment

Serious VF test equipment can accomplish more than just frequency and levels checks. Circuit performance parameters can be obtained from use of a transmission impairment measurement set (TIMS). Test results indicate various aspects of circuit quality. The telephone industry has established standards for many tests such as PAR (peak-to-average ratio), message circuit noise, noise-with-tone, signal-to-noise ratio, three-level impulse noise, phase jitter, envelope delay, noise-to-ground and non-linear distortion, to name a few.

HF test equipment

As the channel modems translate VF signals up to their assigned baseband frequency slots, a method is needed to measure the signal levels of the individual circuits while in the HF frequency range. A frequency selective device is required that can discriminate between the different frequencies on the baseband. Such a device is called a frequency selective voltmeter (FSVM), sometimes referred to as a selective level meter. This piece of test equipment has a variable bandpass "window" that can be tuned to any baseband frequency. It measures the power level (in dBm) of the energy within the bandpass being viewed. This allows measurement of individual multiplexed channel signals while filtering off all other baseband frequencies. The selective voltmeter can measure broadband (3kHz) or narrowband (about 200Hz bandwidth) circuit levels and typically has both flat and C-Msg weighted filters offering different response characteristics.

A spectrum analyzer is another useful tool for viewing baseband levels. There are spectrum analyzers made specifically for baseband frequencies that have their horizontal baseline calibrated to read in terms of channel, group, supergroup and mastergroup numbers. Test tone level can be calibrated on the vertical axis (signal amplitude, in dBm) so that the whole baseband can be evaluated at a glance with regard to signal levels. Hot levels can be easily identified and zoomed in on down to the channel level.

As a tool in gain/loss measurements, a *bridging* HF signal generator may be connected to the baseband and used to inject specific tone frequencies at specific levels. The HF frequency, when de-multiplexed, will produce a VF tone in the DMOD of the associated mux channel that occupies that portion of the baseband.

Video (HF) jackfield

The multiplex system baseband connects to a microwave radio through separate receive and transmit coaxial cables. There should be an HF or *video* jackfield placed between the mux system and the microwave radio so that the two can be electrically isolated for testing and troubleshooting purposes. A monitor jack is usually provided in both the transmit and receive directions. This allows a FSVM, bridging HF signal generator or baseband spectrum analyzer to be plugged into the jackfield to gain access to the baseband without "breaking" the connection and disrupting traffic.

Potential problems

Maintaining proper signal levels is extremely important within an analog multiplex system. Whether they be externally injected test tones or "live traffic," excessive levels can drive analog mux circuitry into non-linear modes that wreak havoc on the baseband. Hot signals can not only splatter over to adjacent channel slots but produce sum and difference frequencies that affect circuits in other areas of the baseband spectrum as well. As mentioned previously, there should not be any signal on the baseband that exceeds TTL.

Another cause of baseband interference relates to poor shielding or bad solder connections in a mux/baseband assembly. Occasionally, local AM broadcast stations, which operate in the same frequency range as the baseband, can be heard on the baseband along with the mux signals. Although such interference typically affects only one or two mux channel slots, it can render those slots useless for "live traffic."

Analog mux modems also require periodic maintenance. The operating frequencies of their on-board oscillators should be held to within ±5Hz to eliminate problems with translation error.

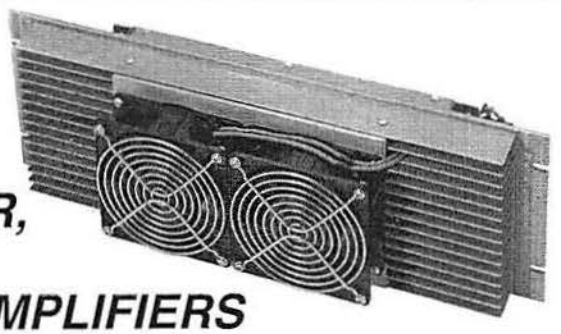
Conclusion

FDM systems have been in use for a long time. Although many of the latest wireless applications are employing digital technologies, active analog mux systems are abundant and employers need qualified technicians to maintain them. Many of these employers have microwave, mux and base stations at their hilltops and would much prefer having one technician "do it all." With a basic understanding of analog multiplex systems, two-way technicians will find themselves better postured in today's job market. ■

Analog multiplexing series

This is part of a three-part series on analog multiplex systems.

Part 1: "Analog Multiplex Systems: The Basics," April 1999.
Part 2: "Analog Multiplex Systems: The Basics," May 1999.
Part 3: "Analog Multiplex Systems: The Basics," June 1999.



REPEATER, PAGING & BASE AMPLIFIERS

200 w. UHF Amps under $1000!
250 w. VHF Amps under $800!
Why Pay More?

For over 20 years, Henry Radio has been manufacturing low cost, reliable mobile amplifiers. All common brands, power ratings and configurations are available.
Call today for specifications and prices or visit our web site:
www.henryradio.com

1.800.877.7979

HENRY RADIO

2050 S. Bundy Drive, Los Angeles, CA 90025
Phone: 310.820.1234 FAX: 310.826.7790
www.henryradio.com

Circle (34) on Fast Fact Card